

Gov. Doc
Can
Ag

A COLOUR DEFECT OF CHEDDAR CHEESE

BY

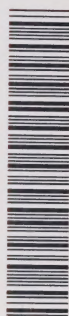
E. G. HOOD, Ph.D.,
CHIEF, DIVISION OF DAIRY RESEARCH

AND

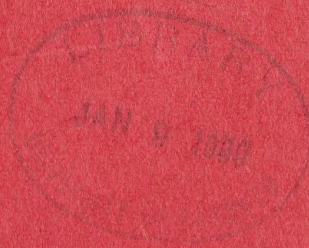
A. H. WHITE, M.S.,
DAIRY SPECIALIST

DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
BULLETIN No. 128—NEW SERIES

Published by direction of the Hon. W. R. Motherwell, Minister of Agriculture
Ottawa, 1929



3 1761 12000355 3



CHIEF OFFICERS OF THE DAIRY AND COLD STORAGE BRANCH

Commissioner.....	J. A. RUDDICK, LL.D.
Chief, Division of Dairy Markets and Cold Storage.....	J. F. Singleton.
Chief, Division of Dairy Produce.....	JOS. BURGESS.
Chief, Division of Dairy Research.....	E. G. HOOD, B.S.A., Ph.D.
In Charge, Enforcement of Dairy Laws.....	D. J. CAMERON.
In Charge, Milk Utilization Service.....	HELEN G. CAMPBELL.
Senior Dairy Produce Grader.....	THOS. J. HICKS.

PRINCIPAL SERVICES ASSIGNED TO THE DAIRY AND COLD STORAGE BRANCH

(1) Grading of Dairy Produce; (2) Scientific Research in Dairying; (3) Study of World's Conditions in Dairying; (4) Correspondence and Advice on all Matters relating to Dairying; (5) Inspection of Perishable Cargoes at Canadian and United Kingdom Ports; (6) Refrigerator Car Inspection; (7) Dairy Market Intelligence; (8) Promoting Uniformity in Dairy Manufactures; (9) Judging Butter and Cheese at Exhibitions; (10) Administration of the Cold Storage Act and Creamery Cold Storage Bonuses; (11) Enforcement of Dairy Laws, and (12) the Utilization of Milk and Its Products.

CONTENTS

	PAGE
Abstract.....	2
Introduction.....	3
Review of the Literature.....	3
Remarks on Samples of Returned Defective Cheese.....	5
Description of the Colour Defect.....	5
Chemical Tests on Defective Cheese.....	6
Bacteriological Examination of Defective Cheese.....	6
Experimental.....	7
Records of Manufacture of Experimental Cheese.....	10
Results of Examination of Experimental Cheese.....	11
Colour Remarks on Experimental Cheese.....	11
Relation of Temperature to the Colour Defect.....	12
Flavour Scores on Experimental Cheese.....	12
Discussion of Results.....	13
Summary.....	13
Conclusions and Recommendations.....	14
Acknowledgments.....	14
References.....	14
Explanation of Figures.....	15
Figures.....	

ABSTRACT

The most important point arising out of this investigation is the fact that the colour defect occurs only in cheese containing saltpeter; all cheese containing saltpeter, however, do not develop the defect. The investigation shows that the discoloration takes place only when the cheese contain certain types of organisms which act in combination with the saltpeter. As the cheesemaker has no means of determining when these organisms are present the only alternative is to discontinue the practice of using saltpeter. While certain advantages are claimed by cheesemakers and others to arise from its use, there is absolutely no scientific or practical evidence to show that saltpeter has any value whatever in Cheddar cheesemaking. On the contrary, there is both practical and experimental evidence to substantiate the fact that its use is extremely detrimental and fundamentally wrong, as it has been known for years that where the quality of the milk and sanitary conditions in the factory have been right, the flavour of the cheese has been found to be satisfactory. With the information now available on this subject, to continue its use is not only inviting trouble and loss to the maker and the trade, but is, as well, jeopardizing the reputation of Canadian cheese.

A COLOUR DEFECT OF CHEDDAR CHEESE

INTRODUCTION

The Cheddar cheese industry provides for the Dominion of Canada a return of no inconsiderable amount. In figures, the total quantity of Cheddar cheese manufactured during 1928 was 143,689,794 pounds, which, when marketed, yielded a return of \$30,313,879. The value of Cheddar cheese exported in 1928 from Canada was \$25,467,642, while the export value of milk and other milk products amounted to only \$10,762,975. In other words, the export value of Cheddar cheese amounted to 70 per cent of the total value of all dairy products exported in 1928.

During the months of October, November and December of 1928 certain consignments of Cheddar cheese from Eastern Ontario were reported as having developed in England a serious colour defect. So far as could be determined from exporters and dealers in Canadian cheese, the defect was entirely new to the cheese trade. Cheese later reported as being defective in colour showed at the time of grading to be of first quality. Records of grading dates to dates of complaints showed that the defect on the average was most striking after the cheese were three to four months of age. While the amount of cheese showing the defect was exceedingly small in comparison with the output exported, nevertheless it was an unmarketable product, which, obviously was a loss to the trade. Complete figures of such losses have not been obtainable, although individual exporters estimated their claims as running into the thousands of dollars. While the monetary loss to the individual dealer or exporting concern may be serious, of much greater importance is the reputation now enjoyed by Canadian cheese in the world's markets. It is needless to say that where competition is keen it is of the utmost importance to provide cheese which will maintain the quality designated at the time of grading in Canada. The country which succeeds in manufacturing the best article and keeping it uniform from year to year will undoubtedly secure a larger trade and obtain the maximum prices.

REVIEW OF THE LITERATURE

Colour defects have been mentioned a number of times in the literature on Cheddar cheese and have very often been the cause of complaints from the trade. As long ago as 1895 a committee of investigation was formed in Scotland to study the causes of cheese discoloration. The report (1) of this committee gave the results of the work of J. R. Campbell, who reported that he had found a bacterium in the cheese which produced an acid capable of destroying the colouring matter of annatto.

In 1897 Connell (2) investigated a case of discoloration in Canadian Cheddar cheese. These cheese had developed small reddish yellow spots throughout which were termed rust spots. This discoloration was found to be due to an infection of an organism which Connell named *Bacillus rudensis* and which got into the milk and curd from badly infected areas in the factory and its surroundings. Similar cases have been reported in American Cheddar cheese.

Several standard books (3, 4, 5, 6, 7, 8) on the manufacture of Cheddar cheese describe defects in colour such as mottled, uneven, seamy, bleached, faded or acid cut. Such colour defects are caused by faulty methods of adding or stirring in the colour in the milk previous to setting, or by faulty methods during the process of manufacture.

Leitch (9) reported an investigation of the discoloration of coloured cheese in which there were irregular bleached patches or areas that were practically devoid of colour. In the earlier stages these areas were more pronouncedly

developed near the rind than towards the centre of the cheese. The same worker (10) also reports an investigation of what he termed black spot in cheese which was found in Scots and English Cheddars both white and coloured. It was also found in Dunlop and Cheshire cheese and has been reported in American and New Zealand Cheddars. The discoloration varies in size from pin points to the size of a shilling and is circular in shape or more rarely is found in the form of veins. Experimental work showed that the discoloration was not of bacterial or enzymic origin, but was due to lead contamination.

According to Orla-Jensen (11), colour defects are important in the case of cheese, as they have ample time to develop and may be caused in several ways. One of the commonest colour defects mentioned is the turning gray or blue of the curd, due to an admixture of salts of iron or copper. Where minute coloured spots are found throughout the cheese, they are caused by the growth of colonies of chromogenic bacteria which grow on the cheese as on other solid media. This is the case with *Bacillus cyaneofuseus*, which causes blue spots in Edam cheese; while the chromogenic propionic acid bacteria form red and brown spots in Emmental cheese.

Orla-Jensen also mentions a form of discoloration resulting in the production of a red colour just inside the rind, which is said to be due to the diffusing of colouring matter from the shelves into the cheese. This explanation does not hold good in all cases, as when cheese are removed to a new place the red zone spreads and the colouration is accompanied by an unpleasant taste. This is likely caused by chromogenic bacteria, both cocci and rod forms, which produce a red colour in cheese.

In this connection Orla-Jensen states that Weigmann has isolated two liquifying organisms, *Micrococcus chromoflavus* and *Bacterium casei fuscum*, which form chrome yellow and cream-coloured colonies respectively on the common media, but which turn the surface of the cheese red. Also Roger has isolated a red organism called *Bacillus firmittatis* from Camembert cheese, which grows only in the decomposition products produced by moulds.

Rosengren (12) states that it is dangerous to use saltpeter in Emmental cheese, even in small amounts, as 10 grams per 100 litres may produce an unclean taste and turn the cheese red.

Cornish and Stenhouse Williams (13) investigated the causes of discoloration in Stilton cheese, which varied from pink to black through many stages of yellow and brown. These workers isolated two groups of organisms, *B. proteus vulgaris* and gram negative alkaline bacteria, from discoloured cheese and from water and milk supplies from the troubled dairies, which were capable of producing colour changes on caseinogen and certain amino acids found in the cheese.

Mason (14) reported a pink discoloration of cheese of the Wensleydale type that was found to be due to a yeast. This discoloration developed quite readily on newly cut surfaces, but was not found in Cheddar cheese, probably due to the texture.

Reiss (15) has experimented using saltpeter in milk to prevent gassy fermentations in certain types of cheese such as Gouda, Emmental and Cheddar. He used between 30 and 60 grams of saltpeter in 100 kilograms of milk, and states that less saltpeter can be used in high acid cheese than in low acid cheese. This worker also found that when too large quantities of saltpeter were used in the milk it produced a reddish colour in the cheese.

A resumé of the available literature shows that several types of discoloration may occur in different kinds of cheese and which may be caused by metallic contamination, by the growth of certain groups of bacteria and by the use of saltpeter. However, since none of the descriptions of the colour defects mentioned in the literature correspond with the type of discoloration found in the present investigation, it is considered to be a new defect in Canadian Cheddar cheese.

REMARKS ON SAMPLES OF RETURNED DEFECTIVE CHEESE

During the latter part of 1928 a number of samples of cheese showing a colour defect were obtained for study through the co-operation and courtesy of Mr. W. A. Wilson, of London, England, through members of the Federal Dairy Staff in England and through the exporting firms in Montreal. The following remarks relating to certain consignments give briefly a general idea of the nature of the defect as met with by the trade in coloured cheese.

Consignments.

1. Network of brownish discoloration. Curd appeared as if it had been washed in muddy water.
2. Badly off in colour, dark lines running through cheese, dark from rind in for 4 to 6 inches.
3. Defective colour showing from bottom of cheese, with less defect in colour from top end. Cheese when cut looked as if two curds had been used in the same hoop.
4. Discoloured through whole cheese.
5. Brownish discoloration.
6. Pink discoloration near rind.
7. Discoloration scattered throughout the cheese in small and large patches.

In other consignments of discoloured cheese similar descriptions of the defect are given.

DESCRIPTION OF THE COLOUR DEFECT

The samples of coloured cheese received at the laboratory showed on examination the following characteristics. In some instances the defect was noticeable in fresh cut sections of the cheese by the presence of a salmon pink colour inside the rind. The pinkish colour, however, varied in amounts and intensities and extended in some cases in patches throughout the cheese. Freshly drawn plugs and cut surfaces of other samples showed variations from the pink to a brownish muddy dead colour. Other samples showed a blending of the normal colour with different intensities of pink and brown, while in the interior of others the muddy brownish colour had developed almost uniformly throughout the entire cheese.

Our attention was directed by a Montreal cheese exporting firm on July 18, 1929, to a vat of white cheese graded on September 6, 1928, that had been returned from England on account of defective colour. Owing to the fact that all previous complaints had been confined to coloured cheese, this condition presented a new angle to the problem. One 100 lb. cheese from this shipment was secured and forwarded to the laboratory of the Division of Dairy Research for examination.

This cheese showed, on examination, the following characteristics. On cutting in two from end to end, the interior showed a dirty brown muddy discoloration throughout the entire cheese, similar to that of some of the defective coloured cheese.

In the white and all of the samples of coloured cheese showing the defect, the flavour was very pronounced and not unlike that of an old whey tank odour.

CHEMICAL TESTS ON DEFECTIVE CHEESE

The attention of the authors was directed to the fact that a number of cheesemakers had been using saltpeter in the process of cheesemaking during the season of 1928. In order to determine if saltpeter was present in the samples of returned defective cheese, tests for the presence of nitrates and nitrites were made. All samples of defective cheese returned to the laboratory showed a strong positive reaction either for nitrates or nitrites, which was proof that saltpeter or nitrates in some form had been used. The results of these tests indicated one of the possible factors in the cause of the colour defect.

BACTERIOLOGICAL EXAMINATION OF DEFECTIVE CHEESE

As samples of defective cheese were returned to the laboratory of the Division of Dairy Research, bacteriological examinations were made to study the type of flora present and to determine whether or not the cheese contained any predominating species. In several of the first samples examined by plating on dehydrated malt agar pH 3.5 and incubated at 25° C. (77° F.), large numbers of yeast colonies developed and on detailed study showed to be in pure culture. On the examination of additional samples the same organisms were found to be present, but only in small numbers; again on plating other samples the yeast was found to be absent. Owing to the fact that a yeast was isolated in pure culture and in large numbers from the first defective samples examined, it seemed probable that some relation existed between this organism and the colour defect. As a result this organism was fully studied and identified as *Chromotorula ochracea* described by Harrison (16). At the time of plating on malt agar, plates were made on nutrient and whey agar and incubated at 37° C. (98° F.) for 48 hours. From these plates 55 representative colonies were picked on to whey agar slopes and incubated for 3 days at 37° C. (98° F.). From these, inoculations were made into nitrate broth, litmus milk and nitrate milk. In litmus milk 33 cultures gave the typical *S. lactis* coagulation. These cultures were not further considered as being related to the colour defect. Of the remaining 22 cultures, 11 showed reduction in nitrate broth in 24 hours, and at the end of 10 days a total of 15 cultures gave positive tests for nitrate reduction. On further systematic study a number of these cultures were found to be similar and the number was reduced to 6.

After the whey and agar plates had been incubated at room temperature for 10 to 14 days, a number of chromogenic colonies developed. In order to study these chromogenic types, three samples of discoloured cheese were re-sampled and plated on whey and nutrient agar and incubated at room temperature for 5 to 6 days, and counts were made of the chromogenic colonies. These are given below.

Sample No.	Age of cheese	Number of chromogenic bacteria per gram
Exp. cheese 2.....	14 weeks	180,000
158.....	9 months	3,200
883.....	9 months	3,700

From these plates 31 representative colonies were picked on to nutrient agar slopes; these were incubated at room temperature for 4 days and transfers made into nitrate broth. After 24 hours incubation at 37° C. (98° F.) 8 cultures were positive, in 60 hours 9 cultures were positive, in 72 hours 11 cultures were

positive, and after 10 days 15 cultures in all gave a strong positive reaction to nitrites, with 8 additional cultures showing a slight positive reaction. In all, 23 cultures of chromogenic bacteria reduced nitrates to nitrites.

The 23 cultures of chromogenic nitrate reducing bacteria and the 6 cultures of non-chromogenic nitrate reducing bacteria were further studied by inoculating into tubes of annatto nitrate milk. This medium was prepared by adding 0.2 per cent of potassium nitrate and .009 per cent of annatto colour to whole milk and sterilizing at 15 lbs. pressure for 20 minutes. After inoculating, these tubes were grown at room temperature for 6 hours, and 2 drops of a 24-hour *S. lactis* culture was added to each tube containing 10 cc. of the milk medium. After incubating for 7 days at room temperature 9 cultures showed the development of a pinkish colour at the surface of the curd.

While the defective cheese has been found to contain a number of nitrate reducing bacteria which produce colour changes in annatto nitrate milk, as yet it has not been possible to attribute the colour defect in Cheddar cheese to any specific organism or organisms. However, it has been shown that the typical colour defect developed when cultures made from defective coloured cheese containing large numbers of nitrate reducing organisms were used in the cheese milk and when saltpeter was added to the curd.

EXPERIMENTAL

Preparatory to the manufacture of experimental cheese, accumulated evidence suggested that consideration be given primarily to the following factors.

1. Annatto Colouring.
 - (a) Normal.
 - (b) Frozen.
 - (c) Aged.
 - (d) From metal drums.
2. Bacterial content of cheese samples showing the colour defect.
3. Yeast content of cheese samples showing the colour defect.
4. The practice of using saltpeter in the process of manufacturing Cheddar cheese.
 - (a) Added to the milk.
 - (b) Added with salt to the curd.
 - (c) The effect of saltpeter on colour in the presence of certain types of bacteria.
 - (d) The effect of saltpeter on colour in the presence of *Chromotorula ochracea* (Harrison).
5. Effect of temperature on the development of the defective colour.

Considering the above factors as having some bearing on the colour defect, 13 vats of experimental cheese were made.

In our experimental work a supply of milk delivered by the Ottawa Dairy to the Central Experimental Farm Dairy was used. In Series I of our experimental work, 320 lbs. of mixed milk were used; from this three cheese of approximately 9 lbs. each were made. The cheese were made by an experienced cheese-maker, following approved practical methods. As soon as each vat of milk was made, one cheese from each vat was held at the following temperatures—

50 to 55° F., 60 to 65° F., and 65 to 70° F. Records of the temperatures in each curing room were made by means of a recording thermograph, and in no case did the temperature exceed the minimum and maximum stated. Series I contained the following experimental vats.

Vat. 1. The cheese from Vat 1 were manufactured from 320 lbs. of mixed milk. To this was added 1.25 per cent of lactic starter and frozen colour carried over from the season of 1928. This colour was secured from factory (X) in which discoloration occurred last year, and was added at the rate of $1\frac{1}{2}$ oz. per 1,000 lbs. of milk. Cultures prepared by inoculating 500 c.c. of sterile milk with 50 grams of discoloured cheese and incubating for 5 days at 25° C. (77° F.) were added to milk at the rate of .62 per cent just previous to setting. This culture was prepared from a discoloured cheese returned from England and was designated throughout the experimental work as cheese 1883.

Vat 2.—The cheese from Vat 2 were manufactured similarly to Vat 1. The only difference to be noted was that at the time of salting, saltpeter was mixed with the cheese salt at the rate of 6 oz. to the 1,000 lbs. of milk and added to the curd.

Vat 3.—The cheese from Vat 3 were manufactured from 320 lbs. of mixed milk. To this was added 1.5 per cent lactic starter and frozen colour similar to that used in Vat 1 and at the same rate. A yeast, *Chromotorula ochracea* (Harrison) isolated from a number of discoloured cheese returned from England, was used in culture in this vat. Cultures were prepared first in milk, but, owing to its slow growth, 100 c.c. quantities of beer wort were inoculated and incubated for 5 days at 25° C. (77° F.). This culture was added to the milk at the rate of .05 per cent just previous to setting.

Vat. 4.—The cheese from Vat 4 were manufactured similarly to Vat 3, with the exception that new colour (1929 supply) was used.

Vat 5.—The cheese from Vat 5 were manufactured similarly to Vat 3. The only difference to be noted was that at the time of salting, saltpeter was mixed with the salt at the rate of 6 oz. to the 1,000 lbs. of milk and added to the curd.

Vat 6.—The cheese from Vat 6 were manufactured from 320 lbs. of mixed milk. To this was added 1.25 per cent of lactic starter and frozen colour carried over from the season of 1928. This colour was secured from factory (Y) in which discoloration occurred last year and was added at the rate of $1\frac{1}{2}$ oz. per 1,000 lbs. of milk.

Vat 7.—The cheese from vat 7 were manufactured from 320 lbs. of mixed milk. To this was added 1.5 per cent lactic starter, colour from the same source and of the same quality as used in Vat. 6. The only difference to be noted between Vat 7 and Vat 6 was that saltpeter at the rate of 6 oz. to 1,000 lbs. of milk was added to the milk previous to setting in Vat 7.

Vat. 8.—The cheese from Vat 8 were manufactured from 320 lbs. of mixed milk. To this was added 1.5 per cent lactic starter and new colour (1929 supply) at the rate of $1\frac{1}{2}$ oz. per 1,000 lbs. of milk. Cultures prepared by inoculating 500 c.c. of sterile milk with 50 grams of discoloured cheese and incubating for 5 days at 25° C. (77° F.) were added to the milk at the rate of .62 per cent just previous to setting. The cheese culture used in this vat was made from a discoloured cheese returned from England and

was designated throughout the experimental work as cheese 1158. Borings made perpendicular to the surface of the cheese and at a point near the edge were used in preparing the culture. At the time of salting, saltpeter was mixed with the salt at the rate of 6 oz. to the 1,000 lbs. of milk and added to the curd.

Vat 9.—The cheese from Vat 9 were manufactured similarly to Vat 8 with the exception that the culture used was prepared from borings taken perpendicular to the surface of the cheese and at a point one-half the distance from the edge. No saltpeter was added to the curd.

Vat 10.—The cheese from Vat 10 were manufactured from 320 lbs. of mixed milk. The usual percentage of lactic starter was used, together with a yeast culture similar to that of Vats 3, 4 and 5. No colour or saltpeter was used.

Observations on the first ten vats of cheese indicated that saltpeter in combination with certain types of organisms were responsible for the discoloration. In order to substantiate further the relation of saltpeter to the discoloration, 3 additional experimental vats were made using 400 lbs. of milk; from this four cheese of approximately 9 lbs. each were made. One cheese each from the treated and untreated curd were held at curing temperatures of 50 to 55° F. and 60 to 70° F., these temperatures were adopted as no apparent difference was noted in the rate of development and type of discoloration between 60 to 65° F. and 65 to 70° F.

Series II contained the following experimental vats:—

Vat 11.—The cheese from Vat 11 were manufactured from 400 lbs. of mixed milk. To this was added .75 per cent of lactic starter and new colour at the rate of 1½ oz. per 1,000 lbs. of milk. Cultures were prepared and added as in Vat 1 of Series I. Previous to salting, the curd was divided by weight. One-half of the curd was salted at the rate of 2½ lbs. per 1,000 lbs. of milk, the other half was salted at the same rate but in addition saltpeter was mixed with the salt at the rate of 6 oz. per 1,000 lbs. of milk before adding to the curd. The two cheese untreated with saltpeter were marked Vat 11 and the two cheese treated with saltpeter were marked Vat 11-0.

Vat. 12.—The cheese from Vat 12 were manufactured from the same amount of milk as in Vat 11 and contained the same amount of starter and colour. Cultures were prepared from discoloured plugs of cheese taken from experimental Vat 2 and added to the milk. As in Vat 11, two of the cheese were untreated and two treated with saltpeter and were marked respectively Vats 12 and 12-0.

Vat 13.—The cheese from Vat 13 were manufactured from the same amount of milk as in Vats 11 and 12, and contained 1 per cent of starter with the same colour and amount. A culture prepared from Vat 2 Series I was used. This culture was prepared by washing with sterile water the surface of three whey and three agar plates. The plates were made by plating out dilutions 1/100, 1/10,000, and 1/1,000,000 from a plug taken from one of the cheese of Vat 2 showing typical discoloration. The agar plates were incubated at 37° C. (98° F.) and the whey at 25° C. (77° F.) for 5 days. As in Vats 11 and 12, two of the cheese were untreated and two treated with saltpeter and were marked respectively Vats 13 and 13-0.

The manufacturing records of experimental Vats 1 to 10 and 11 to 13, Series I and II will be found in tables I and II.

TABLE I
RECORDS OF MANUFACTURE OF EXPERIMENTAL CHEESE—SERIES I

Vat No.:	1	2	3	4	5	6	7	8	9	10
Date.....	3/6	3/7	3/12	3/15	3/14	3/5	3/8	3/20	3/19	3/26
Pounds milk.....	320	320	320	320	320	320	320	320	320	320
Per cent starter.....	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{4}$
Acidity of starter.....	.80	.80	.80	.85	.85	.70	.75	.80	.83	.80
Time set—A.M.....	9.11	9.35	9.57	9.00	9.20	10.50	9.34	8.40	9.02	8.55
Acid at setting.....	.18	.19	.19	.19	.19	.19	.19	.18	.19	.19
Ounces colour per 1,000 lbs. milk.....	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	.....
Rennet per 1,000 lbs. milk.....	4 $\frac{3}{4}$	3 $\frac{1}{2}$	3 $\frac{1}{2}$	4 $\frac{3}{4}$	4 $\frac{3}{4}$	3 $\frac{1}{4}$	3 $\frac{1}{2}$	4	4 $\frac{1}{4}$	4
Temperature set—Fahr.....	86	87	87	86	85	86	86	87	86	87
Time of 1st coag. in minutes.....	11	7	5	5	7	12	6	7	4	6 $\frac{1}{2}$
Time cut—A.M.....	9.39	10.0	10.10	9.11	9.39	11.20	9.54	8.56	9.12	9.14
Time setting to cutting, in minutes....	28	25	13	11	19	30	20	16	10	19
Acidity at cutting.....	.12	.13	.13	.13	.12	.13	.13	.13	.14	.13
Temperature cooked—Fahr.....	99	99	99	100	100	99	99	100	102	99
Whey started—A.M. and P.M.....	12.28	2.00	11.45	11.00	11.50	1.45	12.47	10.55	10.25	11.40
Acid when started.....	.22	.23	.22	.195	.195	.22	.22	.20	.19	.20
Acid when stirred out.....	.26	.30	.26	.26	.27	.30	.26	.26	.26	.28
Time piled—A.M. and P.M.....	12.35	2.07	11.55	11.07	11.57	1.55	12.58	11.05	10.30	11.45
Acidity when piled.....	.29	.30	.26	.26	.27	.34	.27	.30	.26	.34
Time milled—P.M.....	3.10	4.05	2.03	1.15	1.55	4.05	3.03	1.15	12.50	1.40
Acidity at milling.....	.....	.80	.....	.70	.70	.....	.....	.75	.75	.80
Time salted—P.M.....	4.45	5.00	3.50	2.30	3.02	5.15	4.18	2.40	2.30	3.04
Pounds salt per 1,000 lbs. milk.....	2 $\frac{1}{4}$	2	2 $\frac{1}{2}$	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{1}{4}$	2 $\frac{1}{4}$	2 $\frac{1}{4}$	2 $\frac{1}{4}$	2 $\frac{1}{4}$
Temperature of curd after salting.....	84	84	85	84	84	83	82	82	84	84
Bandage placed directly in hoops.....	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time put to press—P.M.....	5.10	5.20	4.05	2.45	3.15	5.25	4.22	2.55	2.45	4.00
Length of time in press—Hours.....	36	36	40	72	36	36	72	36	36	48

TABLE II
RECORDS OF MANUFACTURE OF EXPERIMENTAL CHEESE—SERIES II

Vat No.:	11	12	13
Date.....	4/23	4/24	4/25
Pounds milk.....	400	400	400
Per cent starter.....	$\frac{3}{4}$	$\frac{3}{4}$	1
Acidity of starter.....	.82	.80	.80
Time set—A.M.....	9.10	8.51	8.54
Acid at setting.....	.19	.19	.19
Ounces colour per 1,000 lbs. milk.....	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Rennet per 1,000 lbs. milk.....	4 $\frac{1}{4}$	4 $\frac{1}{4}$	4 $\frac{1}{4}$
Temperature set—Fahr.....	86	86	86
Time of 1st coag. in minutes.....	8	6	9
Time cut—A.M.....	9.32	9.12	9.16
Time setting to cutting, in minutes.....	22	21	22
Acidity at cutting.....	.12	.14	.12
Temperature cooked—Fahr.....	99	99	99
Whey started—A.M. and P.M.....	12.14	11.13	12.00
Acid when started.....	.22	.20	.20
Acid when stirred out.....	.32	.27	.31
Time piled—A.M. and P.M.....	12.25	11.25	12.08
Acidity when piled.....	.32	.27	.31
Time milled—P.M.....	2.50	1.58	1.55
Acidity at milling.....	.....	.....	.....
Time salted—P.M.....	3.25	3.25	3.05
Pounds salt per 1,000 lbs. milk.....	2	2	2
Temperature of curd after salting.....	84	84	84
Bandage placed directly in hoops.....	Yes	Yes	Yes
Time put to press—P.M.....	4.10	3.45	3.20
Length of time in press—Hours.....	36	36	48

RESULTS OF EXAMINATION OF EXPERIMENTAL CHEESE

In table III will be found the graders' remarks on colour of the experimental cheese from Vats 1 to 10, Series I. Vats 1 to 7, manufactured between March 5th and 15th, were first graded on April 15th and regraded on April 30th and May 18th, while Vats 8 to 10, manufactured between March 19th and 26th, were not graded till April 30th and regraded on May 18th. It will be noted that Vat 2 showed the typical colour defect at all of the different temperatures on the first date of grading. On regrading Vat 8 on May 18th, the cheese held at 60 to 65° F. was reported as dead in colour, while a cheese from the same vat held at 65 to 70° F. showed on the same date of regrading the typical muddy colour.

Vats 3, 4 and 5 showed some variation in colour at the different temperatures; the most noticeable changes, however, were slight bleaching and unevenness of colour. Vats 1, 7 and 9 on all examinations showed only slight defects in colour, while Vat 6 was acid cut throughout.

TABLE III
COLOUR REMARKS ON EXPERIMENTAL CHEESE—SERIES I

Vat	Curing temperature 50°-55° F.			Curing temperature 60°-65° F.			Curing temperature 65°-70° F.		
	April 15	April 30	May 18	April 15	April 30	May 18	April 15	April 30	May 18
1	Even.....	Even.....	Even.....	Sl. uneven..	Bleached in patches.	Even.....	Even.....	Even.....	Even.....
2	Pink under rind.	One plug O.K., 2nd plug typically pink.	.....	Typically muddy.	Typically muddy.	.....	Muddy	Muddy.....	.....
3	Sl. uneven..	Uneven.....	Even.....	Even.....	Dull.....	Dead.....	Uneven.....	Even.....	Even.....
4	Sl. uneven..	Sl. uneven..	Even.....	Sl. uneven..	Sl. acid cut.	Even.....	Sl. uneven..	Sl. acid cut.	Even
5	Sl. uneven..	Sl. uneven..	Even.....	Uneven.....	Even.....	Dull.....	Sl. uneven..	Even.....	Sl. bleached
6	Uneven.....	Sl. acid cut.	Acid cut....	Sl. acid cut.	Sl. acid cut.	Acid cut....	Acid cut....	Acid cut....	Acid cut
7	Even.....	Even.....	Dull.....	Even.....	Even.....	Acid cut....	Even.....	Even.....	Even.
8	.....	Uneven.....	Even.....	.....	Uneven.....	Dead.....	.....	Sl. uneven..	Muddy
9	.....	Even.....	Even.....	.....	Even.....	Even.....	.....	Even.....	Bleached
10*	.....	Even.....	Even.....	.....	Even.....	Even.....	.....	Even.....	Even.....

* White cheese.

In table IV will be found the graders' remarks on colour of the experimental cheese from Vats 11 to 13, Series II. These vats were manufactured on the 23rd, 24th and 25th of April, were first graded on May 18th and regraded on May 25th, June 1st and July 2nd. It will be noted that Vat 12-0, held at 60° to 70° F., showed on regrading on May 25th the pinkish defect, while the cheese held at 50° to 55° F. appeared normal. Regrading on June 1st and July 2nd showed varying stages of the colour defect at both temperatures. Cheese from Vat 12 made from the same milk as Vat 12-0 but untreated with saltpeter graded on all dates as even in colour.

Cheese from Vat 13-0 held at low and high temperatures showed about the same degree of discoloration as Vat 12-0, but only after a longer period of storage. Vat 13 made from the same milk as Vat 13-0 but untreated with saltpeter was found on all dates of grading to be even in colour.

Vats 11 and 11-0 were first grade cheese in colour at all gradings.

TABLE IV
COLOUR REMARKS ON EXPERIMENTAL CHEESE—SERIES II

Vat No.	Curing temperature 50°-55° F.				Curing temperature 60°-70° F.			
	May 18	May 25	June 1	July 2	May 18	May 25	June 1*	July 2
11.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....
11-0.....	Not quite true.	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....
12.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....
12-0.....	Not quite true.	Even.....	Discoloured on end.	Pinkish.....	Even.....	Even. Plug near old plug hole showing pink.	Slight pink.	Slight pink
13.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....	Even.....
13-0.....	Daller than No. 13.	Even.....	Even.....	Slight pink in spots.	Even.....	Even.....	Even.....	Slight pinkish.

* Held in Frigidaire at 40°-42° F.

RELATION OF TEMPERATURE TO THE COLOUR DEFECT

At the time of grading the cheese for uniformity of colour, it was found that the curing temperature used had played a very important role in the type of discoloration which developed. This fact was particularly striking in Vat 2. It was found on examining the experimental cheese from Vat 2, which was held for five weeks at 50 to 55° F., that a pinkish colour had developed under the rind, while the experimental cheese from the same vat held at 60 to 65° F. showed no evidence of the pink, but had developed a pronounced dirty muddy colour throughout the entire cheese and typical in every characteristic with that found in certain samples of cheese returned from England. On the second examination two weeks later, the experimental cheese held at the lower temperature had developed the pinkish shades throughout the interior of the cheese, typical in every characteristic of certain other samples of returned cheese, while the experimental cheese from the higher temperature remained unchanged from the first examination. Differences in colour shades and intensities were very marked in cheese from the same vat after seven weeks' storage at 50 to 55° F. and 60 to 70° F. respectively in experimental cheese from Vats 8, 12 and 13. This variation in shades of colour, which developed due to differences in the curing temperatures of the experimental cheese, undoubtedly accounts for and explains the colour variations found in the samples of cheese returned from England.

In table V will be found the graders' score on flavour of the experimental cheese from Vats 11 and 11-0, and 13 and 13-0, in which half the curd was untreated and the other half treated with saltpeter. In comparing the scores of the untreated with the treated cheese no consistent improvement in flavour was shown by the use of saltpeter.

TABLE V
FLAVOUR SCORES ON EXPERIMENTAL CHEESE—SERIES II

Vat No.	Curing temperature 50°-55° F.			Curing temperature 60°-70° F.		
	May 18	May 25	June 1	May 18	May 25	June 1*
11.....	36.0	36.5	36.0	37.0	36.0	36.0
11-0.....	37.0	37.0	36.0	38.0	37.0	37.0
12.....	36.0	36.0	35.0	37.0	36.0	35.0
12-0.....	37.5	36.0	35.0	37.0	36.0	35.0
13.....	39.0	37.5	38.0	38.5	38.0	38.0
13-0.....	39.0	38.0	38.0	39.0	38.0	38.0

* Held in Frigidaire at 40°-42° F.

DISCUSSION OF RESULTS

It is evident from the results obtained in this study that the colour defect develops only when a fixed set of conditions obtain, namely, when the cheese contain certain types of micro-organisms and saltpeter. In the experimental cheese manufactured, discoloration developed only in those cheese which were inoculated with cultures of organisms made from discoloured cheese and had in addition saltpeter added with the salt to the curd. Experimental vats containing similar organisms but untreated with saltpeter failed to develop the defect, while vats with saltpeter added to the milk and curd failed to produce the defect in the absence of bacterial cultures. Experimental vats containing pure cultures of *Chromotorula ochracea* with and without saltpeter showed after a period of curing only slight bleaching of the colour. Experimental cheese made from milk inoculated with bacterial cultures did not develop the defect after three months, while cheese from curd of the same vat treated with saltpeter showed the defect in seven weeks.

Experimental cheese coloured with frozen colour, aged colour, and colour taken from metal drums failed to develop the colour defect. In experimental vats manufactured with the use of aged colour and new colour, the typical colour defect developed only when certain bacterial cultures were added to the milk and saltpeter was added to the curd at the time of salting.

SUMMARY

1. During the fall of 1928 and the spring of 1929 certain consignments of Cheddar cheese from Canada were reported as having developed in England a serious colour defect.
2. The colour defect has been reported in both coloured and white cheese, and so far as can be ascertained, is new in Canadian Cheddar cheese.
3. While the amount of cheese showing the defect is small, considerable financial loss has been experienced because cheese so affected are unmarketable.
4. Affected coloured cheese when bored or cut exhibit varied intensities of colour ranging from normal to pink, reddish, brown and muddy shades. White cheese show dirty brown muddy shades.
5. On regrading, all samples of the defective cheese were no grade on colour, and a second or third grade on flavour, which resembled that of a dirty whey tank odour.
6. Samples of the defective cheese were found on bacteriological examination to contain a number of nitrate reducing organisms capable of producing colour changes in annatto nitrate milk.
7. Chemical tests showed the presence of either nitrates or nitrites in all cheese returned with the colour defect.
8. The typical colour defect developed only in the experimental cheese, which were made from milk inoculated with mixed cultures of organisms and in addition had saltpeter mixed with the salt and added to the curd.
9. The shades of colour which developed in the experimental cheese varied somewhat, depending upon the temperature of curing.
10. Experimental cheese made from milk inoculated with mixed bacterial cultures did not develop the defect after three months, while cheese made from the curd of the same vat of milk that was treated with saltpeter showed the defect in seven weeks.

11. Experimental cheese made from milk coloured with frozen colour, aged colour, and colour taken from metal drums did not develop the colour defect. Cheese made from milk coloured with aged and new colour developed the defective colour only when mixed cultures of bacteria were added to the milk and the curd treated with saltpeter.
12. Cheese made from curd treated with saltpeter failed to show any consistent improvement in flavour quality at different times of grading over cheese made from untreated curd of the same vat of milk.

CONCLUSIONS AND RECOMMENDATIONS

The most important point arising out of this investigation is the fact that the colour defect occurs only in cheese containing saltpeter; all cheese containing saltpeter, however, do not develop the defect. The investigation shows that the discoloration takes place only when the cheese contain certain types of organisms which act in combination with the saltpeter. As the cheesemaker has no means of determining when these organisms are present the only alternative is to discontinue the practice of using saltpeter. While certain advantages are claimed by cheesemakers and others to arise from its use, there is absolutely no scientific or practical evidence to show that saltpeter has any value whatever in Cheddar cheese making. On the contrary, there is both practical and experimental evidence to substantiate the fact that its use is extremely detrimental and fundamentally wrong, as it has been known for years that where the quality of the milk and sanitary conditions in the factory have been right, the flavour of the cheese has been found to be satisfactory. With the information now available on this subject, to continue its use is not only inviting trouble and loss to the maker and the trade but is, as well, jeopardizing the reputation of Canadian cheese.

ACKNOWLEDGMENTS

In connection with the practical part of this investigation, the writers desire to express their indebtedness to Dr. E. S. Archibald, Director of the Experimental Farms Branch, for making available manufacturing facilities at the Farm Dairy; to Mr. Joseph Burgess, Chief of the Division of Dairy Produce; and Mr. T. J. Hicks, Senior Dairy Produce Grader, for their assistance in grading the experimental cheese; and to the latter for his expert services in the manufacture of the experimental cheese.

REFERENCES

- (1) Report of the Committee of Investigation on Cheese Discoloration. 1895-1898. Glasgow. Reprint from the Scottish Farmer.
- (2) Connell, W. T. Discoloration of Cheese. Canadian Department of Agriculture Bulletin. 1897.
- (3) Decker-Sammis, J. L. Cheese Making. 7th Edition, 1924.
- (4) Van Slyke, L. L. and Publow, C. A. The Science and Practice of Cheese Making, 1909.
- (5) Walker-Tisdale, C. W., and Woodnutt, W. E. Practical Cheesemaking. 1917.
- (6) Thom, Chas., and Fish, W. W. The Book of Cheese. 1918.
- (7) Van Slyke, L. L., and Price, W. V. Cheese. 1927.
- (8) Dean, H. H. Canadian Dairying, 1903.
- (9) Leitch, R. H. Discoloration of Cheese. The Dairy, Dec., 1926.

- (10) Leitch, R. H. Black Spot of Cheese. *The Scottish Journal of Agriculture*, Vol. X, No. 2. April, 1927. page 165.
- (11) Orla-Jensen. *Dairy Bacteriology*. Pages 153-155.
- (12) Rosengren. *Dairy Bacteriology* by Orla-Jensen. Page 152.
- (13) Cornish, E. C. V., and Stenhouse Williams, R. Colour Changes Produced by Two Groups of Bacteria on Caseinogen and Certain Amino Acids. *The Biochemical Journal*, Vol. XI, No. 2. August, 1917.
- (14) Mason, G. H. Pink Discoloration of Cheese. *Journal of the Ministry of Agriculture*, Sept., 1920, page 520.
- (15) Reiss, Valberg. Anwendung von Salpeter beim Käsemachen. Abstracted in *Centralblatt für Bakteriologie etc. from Milchwirtschaft Zentralblatt*, 1922, 51. Jahrg. H. 6. S. 68-69.
- (16) Harrison, F. C. Cheese Torulae. *Transactions of the Royal Society of Canada. Third Series*, Vol. XXI, Section V, 1927.

EXPLANATION OF FIGURES

- Fig. 1. A section of a Cheddar cheese from Experimental Vat 2 showing the colour defect. This cheese was cured at 50° to 55° F. for seven weeks, and on cutting showed typical shades of discoloration.
- Fig. 2. A section of a Cheddar cheese from Experimental Vat 2 showing another phase of the colour defect. This cheese, while taken from the same vat as that in Fig. 1, shows a dirty muddy discoloration with almost complete absence of the pink shade. This cheese was cured at 60° to 65° F. for seven weeks, and on cutting showed the colour defect very pronounced.
- Fig. 3. A section of a Cheddar cheese from Experimental Vat 8. This cheese was held at 50° to 55° F. for approximately nine weeks and on examination was graded as even in colour. After cutting and holding for one week at the same temperature the pinkish areas as shown developed. Later observations show that the pink or reddish shades have almost completely replaced the normal colour.
- Fig. 4. A section of a Cheddar cheese from Experimental Vat 12-0. This cheese shows similar discoloration to that in Fig. 3. This cheese was cured at 50° to 55° F. for nine weeks, and on cutting showed the characteristic colour defect.
- Fig. 5. A section of an experimental Cheddar cheese. This cheese was taken from the control cheese of Vat 12 and cured at 50° to 55° F. for ten weeks. The normal colour is shown in contrast to the discoloration in cheese Fig. 4 from Vat 12-0. The variation in colour of Figs. 1, 2 and 3 is most striking in contrast to the normal as shown here.
- Fig. 6. A photograph of a section of discoloured cheese which was returned from England. The lower portion of the photograph shows the typical muddy brown colour, while the upper part has remained normal.







3





5



PUBLICATIONS ON DAIRYING

The following Publications of the Dairy and Cold Storage Branch, Department of Agriculture, are available on application to the Publications Branch, Department of Agriculture, Ottawa.

NEW SERIES

BULLETINS:

- No. 14 The Testing of Milk, Cream and Dairy By-Products by Means of the Babcock Test.
- " 16 Small Cold Storages and Dairy Buildings.
- " 47 Cheese Factory and Creamery Plans and Specifications.
- " 48 The Cause and Prevention of Mould in Canadian Pasteurized Butter.
- " 57 Buttermaking on the Farm.
- " 59 The Pasteurization of Milk, Cream and Dairy By-Products.
- " 61 Cold Storage for Creameries.
- " 67 The Grading of Dairy Produce in Canada.
- " 70 Canada Creamery Buttermaking.
- " 79 The Composition of Canadian Cheddar and Process Cheese.
- " 102 The Manufacture of Ice Cream.
- " 109 List of Cheese Factories and Creameries in Canada and Registered Numbers.

PAMPHLETS:

- No. 2 Simple Methods for the Storage of Ice.
- " 7 Why and How to Use Cheese.
- " 13 Keeping Dairy Herd Records.
- " 24 Is Cow Testing Worth While?
- " 28 The Cooling of Milk for Cheesemaking.
- " 36 Why and How to Use Milk.
- " 37 The Care of Cream for Buttermaking.
- " 44 The Finch Dairy Station: A Further Report of Progress.
- " 49 Home-made Frozen Desserts.
- " 52 Neutralization of Cream for Buttermaking.
- " 67 An Argument in the Kitchen.
- " 91 Surface Taint Butter.
- " 92 Studies on Moulds and Yeasts in Creamery Butter.

CIRCULARS:

- No. 5 Why and How to Use Skim-Milk.
- " 6 Why and How to Use Cream.
- " 7 Why and How to Use Cottage Cheese.
- " 8 Why and How to Use Buttermilk.
- " 9 The Branding or Marking of Cheese and Butter Boxes.
- " 18 Causes of Variation in the Percentage of Fat in Hand Separator Cream.
- " 20 Vat and Churning Numbers on Cheese and Butter Packages.
- " 33 Marking Vat Numbers on Cheese and Cheese Packages.
- " 43 Milk Drinks.
- " 47 Cold Storage Temperatures.
- " 50 Notes on the Cold Storage of Eggs.
- " 68 Yield and Relative Value of Some Dairy Products.

ACTS, ORDERS AND REGULATIONS:

- " 19 The Cold Storage Act, 1907, as Amended in 1909, and Regulations.
- " 26 The Dairy Industry Act and Regulations.
- " 27 Regulations Governing the Inspection of Condensed, Evaporated and Dried Milk.

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1629